

Feature

Achieving Productivity from Abrasive Blast Cleaning Systems

By Clemco Industries

Abrasive blasting of steel substrates can provide the best possible surface preparation for coatings adhesion. If done properly, abrasive blasting thoroughly cleans the surface and creates a surface profile for mechanical adhesion. To achieve the economy available through abrasive blasting, the operator must maintain the productivity and efficiency of the cleaning system through careful attention to all of its components.

The principle of air-supported abrasive blasting is very elementary. Compressed air propels abrasive particles at high velocities to impact and clean a substrate.

All the equipment between the air compressor and the emission of abrasive particles is used to supply, convey, and accelerate the abrasive.

Three basic components are found in most abrasive blasting operations: the equipment, the abrasive, and the personnel. Careful attention to these 3 basic components is the key to the success or failure of the entire operation.

Equipment

For abrasive blasting, as with any discipline, efficiency and productivity are directly affected by the appropriateness of the tools that are used.

Air Compressor

The air compressor is one of the most critical pieces of equipment in the entire operation. It is also one of the most costly, and demands proper maintenance. Because the volume and pressure of the compressed air determine the speed of the abrasive as it exits the nozzle, and thus its cleaning productivity, maintenance of air volume and pressure is critical.

The size of the blast nozzle's orifice will determine the size of compressor required to achieve a given psi of air at the nozzle. Reductions in pressure affect blast cleaning efficiency. For example, if 100 psi is taken as a standard providing highest (100 percent) productivity, then a nozzle pressure of 80 psi will result in 66 percent blasting productivity, while a nozzle pressure of 60 psi will result in 50 percent blasting productivity.

Table 1 shows the effect of nozzle orifice size on compressed air requirements. For instance, when a 3/8-inch nozzle orifice is used, 196 cfm of air is required to achieve 100 psi of air at the nozzle and a 44 hp compressor is needed.

Two factors can influence compressor size requirements, in addition to nozzle orifice size. They are pressure and air volume loss due to hoses and couplings, and the use of the blast machine compressor to supply breathing air for respirators.

Pressure and air volume are lost when undersized hoses and couplings are used to join the compressor to the blast machine. The air hose should be at least 1.5 in. inside diameter(I.D.) and preferably 2 in. or larger. Keep in mind that for every pound of pressure lost at the blast nozzle, there is approximately 1.5 percent loss in blasting production. If because of undersized air hose the air pressure is reduced by 10 psi, blasting production will be reduced by 15 percent. Pressure and volume loss can be minimized by keeping the I.D. of the air hose and couplings a minimum of 4 times the size of the blast nozzle orifice.

If blasting operators acquire breathable air for their respirators from the same compressor that is used for the blast machine, then the amount of air required by the respirators must be added to the amount of air required by the blasting nozzle(s) to calculate the size of compressor needed for the operation.

The diameter and length of blast hose that conveys the abrasive to the nozzle can also cause pressure loss, but this factor will be discussed in the next section.

Outdoor blasting usually dictates the use of a portable gasoline or diesel engine compressor, while in-plant blasting needs are best served using a stationary, electrically driven compressor. With either, it is necessary to have clean, dry air supplied at the correct volume and pressure.

Abrasive Blast Machine

The abrasive blast machine must be an ASME-coded vessel, designed to meet all safety laws. Blast machines are designed and chosen primarily for their abrasive capacity and if required, for their portability. Their overall design, however, is an essential factor in their efficiency and productivity. For proper functioning, the air pressure inside the blast machine must be equal to the air pressure flowing through the external piping. While there are relatively few moving parts, the machine should have certain features to increase its efficiency. These features include an automatic filling valve (pop-up valve) that seals when air is supplied to the machine and opens when air is turned off, a concave head for ease in filling with abrasive, and a conical bottom that permits the smooth and complete flow of abrasive into the abrasive metering valve.

The external piping on any high production blast machine should be at least 1 in. I.D. and preferably 1.25 in. I.D. One in. I.D. is suitable for those blasting operations using up to 5/16 in. orifice nozzles. For 3/8 in. or larger nozzle orifice sizes, 1.25 in. I.D. is applicable. All piping, valves, and fittings must have full air flow capabilities. The use of small, restrictive piping and valves will cause pressure loss by reducing air volume and will prevent steady, uniform abrasive flow. It is of no value to use large diameter piping and then restrict the entire system by using even 1 undersized valve or fitting.

A critical component of the blast machine is the abrasive metering valve. Its design should allow for quick, precise adjustment of abrasive flow into the compressed air stream. A 45-degree angle of abrasive feed into the air stream has been found to be very efficient because at this angle the abrasive tends to merge uniformly with the air flow.

It should have good abrasive metering capabilities because too little abrasive can give an uneven distribution of particles in the blast pattern. This causes much slower cleaning rates and can leave some surface areas untouched. Excessive abrasive interferes with the abrading action because of abrasive impacting other rebounding particles. The optimum metering adjustment gives a very fine flow of abrasive that can be seen exiting the blast nozzle in a smooth and steady flow.

In addition to smooth and easy adjustability, the metering valve should have quick clean-out capabilities when foreign materials cause plugging.

Remote controls are an absolute necessity, both for the overall productivity of the blast operation and to satisfy OSHA requirements for the safety of the operator. Remote controls allow the blast operator to start and stop the machine AT THE NOZZLE, thus keeping abrasive and air consumption to a minimum because the operator does not have to rely on a blast machine tender to turn the machine on or off.

Remote controls can, however, be a detriment to air flow if they are not properly designed or sized for the machine. Like the machine piping, remote control valves must be large enough to handle the air requirements of the system.

There are 2 basic types of remote controls: pneumatic and electro/pneumatic. Electro/pneumatic remotes should be used on jobs that require over 100-foot runs of blast hose because they respond much faster than pneumatic remote controls.

The sole purpose of blast hose is to convey the air-driven abrasive from the blast machine to the blast nozzle. The abrasive/air mixture should flow freely without passing through any undersized hose or fittings that could cause excessive wear and pressure loss.

If the blast hose I.D. is decreased by only 1/4 in., the pressure loss can be as great as 12 psi. The I.D. of blast hose that is used in high production operations should be at least 1 in., but preferably 1.25 in. When the I.D. of

hose is doubled, the inner area of the hose is quadrupled. The opposite is true, of course, when the hose I.D. is reduced. [Table 2](#) shows hose I.D. and area size and the reduction of area as the I.D. is decreased.

Any coupling that is used on a blast hose should allow a smooth transition between hose lengths of any I.D. The coupling must not interfere with the flow of air and abrasive, and the coupling should only be of the external fitting, quick disconnect style. In addition, if the coupling does not include automatic safety wire connections in its design, safety wires must be used to help prevent the accidental disengagement of the quick couplings. Hose safety cables are also available for use on both air and blast hose.

It is important to minimize the length of the blast hose, because this factor also causes pressure loss. In normal operations 4 to 5 psi of pressure is lost due to friction in each 50-foot length of blast hose.

Nozzles

Blast nozzles are designed to meet a wide variety of needs, and they are supplied in various lengths and configurations. In addition, various materials are used for both the liner and the outer jacket. Proper nozzle selection depends upon the surface to be cleaned, the size of the overall job to be done, the amount of compressed air that is available, and the type of abrasive to be used. When the air and abrasive reach the blast nozzle, the nozzle design should allow for rapid acceleration of the mixture to be evenly dispersed in a high velocity pattern.

Of the nozzle styles that are currently available, long venturi types provide the highest velocity and most uniform blast pattern. A straight barrel nozzle provides abrasive/air exit speeds of up to 318 ft/sec, while venturi nozzles provide abrasive/air exit speeds of up to 660 ft/sec ([Fig. 2](#)).

Modern nozzle liner materials are usually manufactured from ceramics, tungsten carbide, boron carbide, or silicon carbide. Outer jackets can be of aluminum, zinc die metals, steel, or urethane. Common ceramic liners wear fast and unevenly, giving the operator very little control over the work being performed. Fast and uneven wear can overtax the air compressor, causing an inevitable loss of air pressure that will create a substantial drop in production rates.

Nozzles lined with tungsten carbide, boron carbide, or silicon carbide give longer hours of service with minimal wear, assuring a more consistent air and abrasive supply over long periods of nozzle use. The most popular liner materials are tungsten carbide and silicon carbide, which are suitable for use with most expendable and re-usable abrasives. Boron carbide liners are more expensive than tungsten or silicon carbide liners and are generally used only with the most aggressive abrasives, such as aluminum oxide.

While the hardness and composition of the nozzle liner can allow longer wear, these same qualities can make the liners very brittle and susceptible to premature fracture if the nozzle is misused. The use of soft urethane as a

nozzle jacket material has provided an extra measure of protection against impact while reducing the overall weight of the nozzle.

The fastening end of the nozzle has traditionally had 1.25 in. fine threads, or occasionally, a flange fitting. The newest fastening form is with 50-millimeter threads that are larger, deeper, and stronger than fine threads. In addition, 50-millimeter threads help prevent thread gall, which can occur when abrasive lodges in the threads as the nozzle is put in and taken out of the nozzle holder.

Nozzle orifice size is very critical to productivity. The orifice diameter determines air volume requirements at given nozzle pressures as well as abrasive consumption and cleaning production rates. All work accomplished will be in direct proportion to the volume and pressure of air that exits the nozzle.

The best nozzle length depends upon several factors. The accessibility of the operator to the work, the type of surface to be cleaned, and the amount of surface to be cleaned are 3 considerations. Generally, a short nozzle, 3 in. long, is used when the surface area is small or when the cleaning job is very easy, such as raised and flaking paint. On hard to clean surfaces, such as rusted and pitted steel or tight mill scale, a long venturi nozzle is the most efficient.

Since the air pressure that exits an air compressor is always higher than nozzle pressure, a nozzle pressure gauge must be used to measure the actual pressure at the nozzle. Once again, the work performed is in direct proportion to the volume and pressure at the blast nozzle.

Abrasive Selection

Abrasive selection is determined by the scope of the job, the job location, and the desired surface finish, which may be determined by the coating manufacturer or the owner of the equipment or structure that is being cleaned. A wide variety of abrasives is readily available throughout the world, and any of several types may be chosen to accomplish the required surface cleaning.

In the very broadest sense, there are 2 basic types of blasting abrasives: expendable and re-usable. Sand and slag are 2 examples of expendable abrasives normally used outdoors. Steel grit and aluminum oxide are 2 re-usable abrasives normally used in a blast room or blast cabinet where there is some type of reclaim system. Generally speaking, sand and slag are used once and then disposed of; steel grit and other metallic abrasives have a very high re-use factor.

There are 4 important features that affect performance of any abrasive: hardness, shape, size, and cleanliness.

Hardness dictates the friability or breakdown rate of most abrasives; hard abrasives fracture or pulverize easily upon impact. Hard abrasives are used

on surfaces where the material to be removed is tenacious or where a deep profile is required.

Abrasive shape will determine the surface etch or surface profile. Angular, sharp particles produce the greatest cutting action and the deepest profile. Round or semi-round particles will cut much more slowly and will produce a more shallow profile. This one feature has caused more problems with production rates than any other characteristic.

Size is a very critical aspect of any abrasive selection process. Properly sized abrasive has a major effect on coating coverage and coating adhesion. A coarse particle will produce a deep profile, while a finer particle will produce a more shallow profile. Excessively deep or shallow profiles can cause major coating problems and failures. When a profile is too deep for the applied coating, peaks will protrude through the coating surface allowing premature coatings failure. Shallow profiles do not provide a sufficient roughness for bonding. Achieving the specified profile depends upon selecting the right size range of abrasive.

The final prerequisite for abrasive is cleanliness. Abrasives should be washed and screened to remove any contaminants, dust, or fines. Dust and fines reduce cleaning rates and can interfere with surface profiles. In addition, contaminants, such as soluble salts, can ultimately cause premature coating failure.

Personnel

Equipment that has been properly selected for the job and the correct abrasive for the surface to be cleaned produce the necessary “power” to operate at a consistent pace. It is the operator, however, who controls the equipment and determines the ultimate productivity and job efficiency. Operators therefore must be properly trained and protected from the health and safety hazards of abrasive blasting.

In nearly all trades, the cost of labor is at least equal to if not higher than the cost of equipment and supplies. Personnel can make or break any abrasive blasting job. Properly trained, abrasive blast operators can turn an otherwise potential failure into a profitable operation. They should be trained in the use of the equipment, safety, proper blasting techniques, control of surface profile, surface cleanliness standards, and coating manufacturers’ requirements for the end condition of steel for each coating used.

Operators who are well trained on the equipment will be able to tell instantly if it is functioning at full capacity. If it is not, they will be able to make appropriate adjustments in techniques or equipment set-up. Adjustments in technique might include nozzle angle, nozzle distance from the surface, and nozzle dwell time. Adjustments in equipment set-up could include changing air pressure, adjusting the abrasive metering valve, or using different diameter hose.

Every operator must be protected in his work environment, for his own safety and for the safety of those workers who may be in the same area. Abrasive blast operator safety regulations are set by local, state, and federal agencies. All abrasive blast operators must wear NIOSH- (National Institute of Occupational Safety and Health) approved, air-fed helmets or hoods. This equipment must be supplied with at least Class D breathing air.

In the case of supplied air from the blast machine compressor, a carbon monoxide alarm or converter, an overheating alarm, and a breathing air filter are essential. The filter will remove light oils and mists and some odors that are usually associated with air compressors that require oil for lubrication. The carbon monoxide alarm will alert personnel to the presence of potentially injurious levels of carbon monoxide that may be in the breathing air supply. The converter can remove dangerous levels of carbon monoxide.

Typically, air compressors will raise the air temperature above ambient. There are lightweight devices attached to the operator's belt that will cool or even raise the temperature of the compressed air that is supplied to the operator.

Complete blast suits, which are made of breathable cotton fabric that is leather-faced, and leather gloves round out the operator safety equipment. Because an operator's productivity can be greatly affected by his comfort or discomfort, it is important to select safety clothing and equipment that minimize weight, heat, and impediments to movement.

After considering the essential elements that make abrasive blasting systems productive, it is still difficult to estimate production rates. The variability of system set-ups, the operator's skill or lack thereof, the condition of the surface to be cleaned, abrasive characteristics, and environmental considerations make any calculations merely estimates. [Table 3](#) , however, provides general guidelines on production rates based upon accumulated field data. The data presume that 100 psi is maintained at the blast nozzle.

Conclusion

It is well known that correct surface preparation is essential to achieving the full life of any coating or coating system. Abrasive blasting is recognized as the most effective means of obtaining the correct surface cleanliness and surface profile. Careful attention to all the components of an abrasive blasting system, including the air supply, the abrasive blast equipment, the abrasive, and the expertise of the operator, can assure that any abrasive blasting operation obtains its maximum level of efficiency.

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